R&D of a PEM Fuel Cell, Hydrogen Reformer, and Vehicle Refueling Facility (Las Vegas Energy Park)

Project ID # TVP12

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2006 Hydrogen and Fuel Cells Merit Review Meeting
Washington, DC
May 2006

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AIR PRODUCTS

Las Vegas Hydrogen Fueling and Energy Station – Compression, Storage and Fueling

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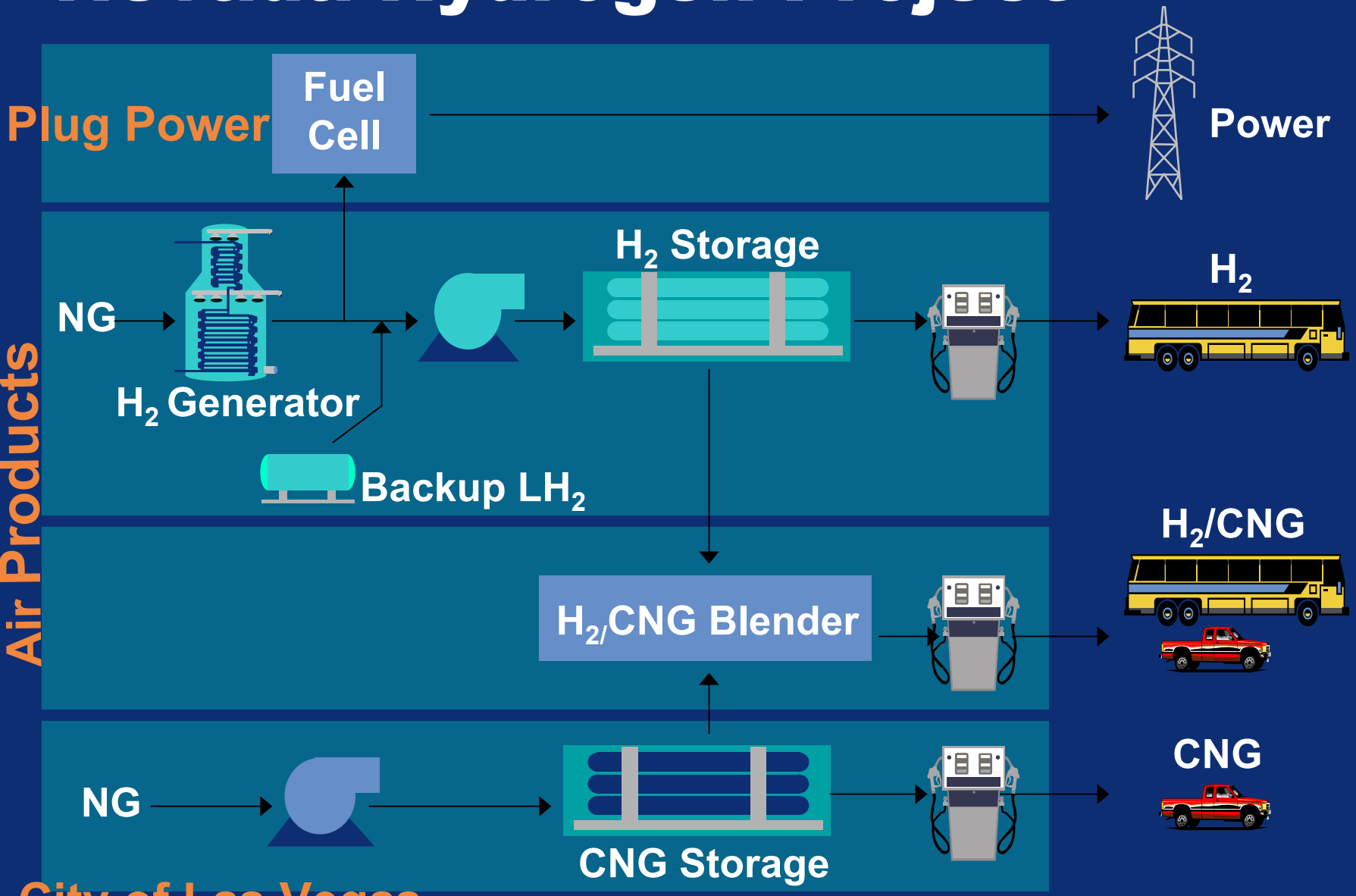
Las Vegas Hydrogen Fueling and Energy Station – Distributed Hydrogen Generation and PEM Fuel Cell Power Generation

Nevada Hydrogen Project



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Program Objectives

Done
- Demonstrate small, on-site H_2 production for fuel cell power generation and H_2 fueling station

Done
- Demonstrate multipurpose vehicle refueling station to dispense H_2/CNG blend and pure H_2

Done
- Demonstrate H_2-fueled stationary 50kW fuel cell

Done
- Evaluate operability/reliability/economic feasibility of integrated power generation and vehicle refueling designs

Done
- Expand the current facility for 350 barg pressure filling to support vehicle needs.

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Budget

- Total Project Budget:
  - $13,118,282

- FY2006 Funding
  - Total = $169,160
    - DOE = $84,580
    - Air Products = $84,580

DOE Technical Barriers

DOE HFCIT Multi-Year Plan

- Technology Validation
  - B. Storage – Cost, Performance, Structural Integrity
  - C. Hydrogen Refueling Infrastructure – Cost of Hydrogen, Low Availability, Safe Systems
  - D. Maintenance & Training Facilities – Operating and Maintenance Requirements, Personnel Training
  - E. Codes & Standards – Lack of Adopted Codes and Standards
  - I. Hydrogen and Electricity Co-production – Cost and Durability, Permitting, Safety Procedures

DOE Technical Targets

DOE HFCIT Multi-Year Plan

- Technical Targets
  - Reformer Efficiency, 2003, %(LHV) – 70%
    - Vegas result, 2000 design – 68% (current test data)
    - Test data collected while producing < 1 ppm CO purity
    - Vegas has capability to meet target; additional operation to demonstrate capability
    - PSU Program has delivered improvements to 2005 targets
  - Cost of Hydrogen, 2003, $/kg - $5.00
    - Vegas result - < $5.00
    - Based on evaluation of Las Vegas Energy Station performance using HFCIT MYPP assumptions
    - PSU Program has delivered improvements to 2005 targets

Technical Approach

- Design, Build, Test
  - Scaled extension of research
  - Real-world performance and durability testing
  - Site selection, permitting, safety, operability, reliability, maintenance experience clarifies research and development gaps

- Severe Test Environment – Las Vegas
  - Desert climate – high summer temps, occasional freezing temps in winter
  - 2000 feet above sea level
  - CO_2 non-attainment (Clark County)

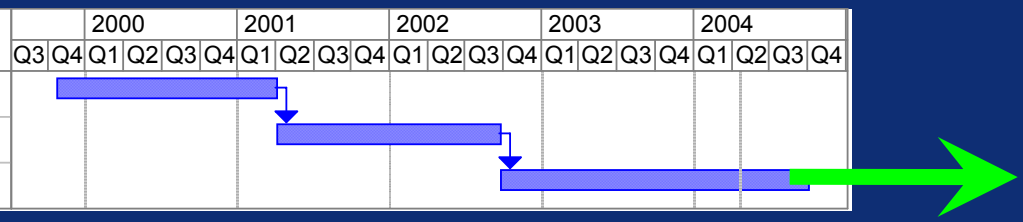
Technical Approach

- Phase 1
  - Definition of System Requirements
  - Finalization of System Definition to Requirements
  - System Engineering and Design
- Phase 2
  - Equipment Manufacturing
  - Detailed Design for Integrated System Installation
  - Installation, Commissioning and Start-up
- Phase 3
  - Demonstration, Operation and Maintenance
  - Data Collection and Analysis
  - Feedback to Future Designs
  - Selection of Existing System Improvements

Current Status: Final Report in Progress- PROGRAM COMPLETE

Project Timeline

ID	Task Name
1	Phase 1 - Engineering and Design
2	Phase 2 - Manufacture, Install, Start-up
3	Phase 3 - Operation Period



- Hydrogen Generator start-up at site achieved August 2002
- Site opening dedication held in November 2002
- Two-year demonstration operating period completed
- Operating demonstration extended into 2007 with support from CLV and federal funding

Technical Accomplishments – Hydrogen Generator

- **Overview**
  - Over 4800 hours operation
  - Satisfactory process operation and product purity capability
  - One button start, load following, additional features
  - Remote monitoring from Allentown, PA & Sacramento, CA
  - Added vehicles demand
- **Performance**
  - 68% LHV efficiency achieved w/ year 2000 design basis equipment , < 1 ppm CO purity control
  - Sound process technology implementation
  - Interim inspection of equipment showed equipment in good mechanical condition

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Technical Accomplishments – Hydrogen Generator (Cont)

- **Operating Experience Information**
  - Severe diurnal cycling affects ambient conditions, influencing process dynamics
  - Seasonal ambient changes influence process dynamics
  - Steam system dynamics and control
  - More than sufficient instrumentation for safe and reliable control system
  - Lessons Learned fed to Air Products, Penn State, and Power Park (Hydrogen Energy Station) Project Teams
- **Operating Test Campaign**
  - Added primary air flow measurement
  - Added steam flow measurement
  - Added thermocouples along reformer tube to monitor thermal stratification
  - Completed 2000 hour on-purpose test run successfully
  - Collected performance test data.

Technical Accomplishments –
Fueling for 2005

- Upgrade to 350 Bar H_2 fueling
- Over 200 combined vehicle fuelings for H2 and HCNG vehicles
- Supporting CLV operation of two HCNG ICE blend Ford F-150 trucks, converted in cooperation with the DOE.
- Additional HNCG vehicles will be added to fleet by CLV and DOE.
- Supporting CLV operation of two Honda FCX fuel cell vehicles as part of the CLV fleet.

Economic Modeling Update - 2005

- Incorporated data and information on fuel cell activities from DTE efforts on more recent Plug Power fuel cells.

- Latest FC data and Las Vegas Energy Station performance using HFCIT MYPP assumptions, results in:
  - Hydrogen price of $3.54/Kg
  - Power at $0.08/Kwh
  - Assuming a NG price of $4.50/MMBTU for a 1500Kg/day plant. Increased production and lower NG price than 2003 calculations.

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Honda FCX Fueling at City of Las Vegas

HONDA

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Responses to Reviewers' Comments

- **Educational Benefits**
  - Significant international and national visitor traffic
  - International Energy Agency
  - DOE Safety Panel
- **Vehicles**
  - CLV has obtained funding for continued operation and funding of vehicles. We will continue to assist in this objective.
  - 4 vehicles were converted to HCNG; 5 more in progress
- **Expanding Operations**
  - Continue to use the facility as an arid climate test site under the Validation and Demonstration Program.
  - Add capabilities as needed to meet the above objective.

Future Work

- **Concluding current program**
  - Analyze data collected for final report
    - Incorporated lessons learned into PSU
      - H_2 Generator Packaging
      - H_2 Generator Process and Control Improvements
      - System Design, Costs and Economics
  - Support CLV fleet expansion

- **Planning for continued DOE support of site beyond current project**
  - Continued use of Vegas asset as a R&D test bed facility
  - Support Vegas Fleet build-out
    - City currently has 4 blend trucks, 2 Honda fuel cell vehicles
    - Current fleet of 268 CNG vehicles
    - Progressive in testing / adopting alternative fuels

Collaborations

- DOE HQ and Golden Field Office
- Dan Hyde, City of Las Vegas Fleet Site Mgr
- Plug Power
- Sandia National Laboratory
- International Energy Agency
- DOE Safety Panel

Thank you.

tell me more

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Publications / Presentations

- DOE Annual Review Meeting – 2000-2004
- Mentioned in Presentations at:
  - DOE Regional Meeting in Annapolis, MD - 2004
  - SAE Annual Meeting – 2004
  - NHA Annual Meeting – March 2005

Hydrogen Safety

- **The most significant hydrogen hazard associated with this project is described below:**
  - *This is a comprehensive project that includes the operating demonstration of an integrated hydrogen generation, hydrogen refueling, and CNG/hydrogen refueling station. As such, several potentially hazardous situations are possible and are covered in Air Products' safety and design reviews. The detailed HAZOP identifies the hazards and the safety measures taken to mitigate them.*

Hydrogen Safety - Approach

- **Our approach to safety issues is comprehensive and is based upon a tremendous experience base:**
- **Safety**
  - Air Products has >40 years' experience in safe design, construction, & operation of H_2 plants.
    - > 12,000 H_2 fuel fills complete to date (>75-120 per week now)
    - Leader in Management of Change, Near Miss Reporting, and Quantified Risk Assessment Procedures
  - PHR: Phase 1
  - HAZOP: Phases 2 & 3
  - All applicable industry codes are followed
  - Air Products participates in SAE, ICC, ISO, HFPA, IETC, and EIHP2 committees.
- **Site Selection and Personnel Training**
  - Site concurrent with CLV fleet garage
  - Personnel are trained in H_2 handling and maintenance of H_2-related equipment